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HYDROGEN ION CONCENTRATION OF THE CONTENTS OF THE SMALL INTESTINE

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The contents of the small intestine were removed by swallowing a tube 7 feet long so far down that the outer end was at the teeth and there were no loops or coiled portions in the stomach. The tube was of smooth rubber, 1.5 mm. internal diameter and 3.5 mm. external diameter, and hence stiff enough to keep from collapsing. A 6-gram iron sinker was attached to the lower end to assist in the introduction of the tube. The swallowing movements of the oesophagus acting on this sinker pulled the tube down. When the tube reached the pylorus, the subject reclined on his right side with hips elevated so that the sinker would pass through the pyloric sphincter. This passage was accomplished more easily on an empty stomach, in fact, in one subject who swallowed the tube after a meal, passage of the pylorus was not accomplished until about 4 hours had elapsed and repeated trials did not lessen the time required. On an empty stomach, passage was accomplished immediately in two subjects, as demonstrated by the fact that a darkly bile-stained fluid flowed out of the tube. Bile may be regurgitated into the stomach, but is then diluted with gastric juice and saliva. The tubes were kept down in two subjects for 5 days and 4 nights. The subjects ate their meals regularly, went to lectures, went swimming, automobile riding, slept soundly, and, in fact, the only inconvenience experienced was consciousness of the presence of the tube in the throat owing to its stiffness. To alleviate this annoyance they ate ice cream and bananas during the afternoon. The withdrawal of the tube with sinker attached caused no inconvenience. It required the tube about 5 days to descend to its full length and it was examined each day with the fluoroscope by Dr. F. S. Bissell, the antimony in the rubber casting a distinct shadow.

The tube was kept clean by forcing distilled water down it when not in use. Samples of intestinal contents could be obtained only when digested food was coming down from the stomach. At other times hardly a drop of fluid could be obtained. The H ion concentration of the individual samples are without apparent significance, but the average figures for each day show the contents to become less acid as the tube descended farther. The average figure for the 1st day was $10^{-4.7}$, 2nd day 10^{-5}, 4th day $10^{-5.1}$, and 5th day $10^{-6.2}$. The intestinal contents, when incubated at body temperature with boiled egg-white, showed hardly any proteolytic action. Probably egg-white requires to be swollen by the acid in the stomach before rapid proteolysis can take place. Egg-white will swell also in alkali, but the intestinal contents were near the isoelectric point of egg albumin, at which least swelling occurs.

On taking a census of laboratory workers, I found they all considered the intestinal contents as being alkaline, and, in order to account for this erroneous impression, reviewed the literature since the days when physiologists, ignorant of the germ theory, tasted body fluids to see whether they were acid or alkaline. Von Helmont, in 1648, found that the taste changed from acid to salt on passing from the stomach to the intestine. After the discovery of indicators, Tiedemann and Gemlin, in 1826, found that the soda from the common bile duct unites with the acid chyme and makes it less acid. In 1891, Macfadyen, Nencki and Sieber, with the aid of a grant from the Elizabeth Thompson Science Fund, studied the outflow from a fistula in the ileum of a patient continuously for 6 months and found it always acid. It seems strange, therefore, that the popular notion is that the intestine is alkaline and I cannot account for this unless it is due to the fact that the secretions of the pancreas and the glands of Brunner and Lieberkuhn in the intestine are alkaline as shown by titration and with the hydrogen electrode. They are not sufficiently alkaline to neutralize the acid chyme.

My determinations were made with the hydrogen electrode and after 5 years' experience with biological fluids, I have begun to feel confident of determinations without the precaution of triplicate and quadruplicate samples. Palladium electrodes are attacked by acid of the stomach and sometimes of the duodenum. I use gold electrodes plated bright with iridium. By using a very concentrated solution of iridium chloride the plating can be done in about 2 minutes, and the electrode may be used longer without replating than when plated with platinum, and is easier to clean because it is bright. In non-viscous fluids the electrode must be entirely immersed in the sample, and the latter kept saturated with hydrogen gas by shaking. The presence of oxygen gives a low voltage to the hydrogen-calomel cell. In such cases the voltage rises after the shaking has ceased. The acidity of the intestine aids in the preservation of the antiscorbutic vitamine while it is being absorbed. Feeding of lactose changes the intestines of guinea pigs from alkaline to acid.